

Challenges With The Integration of Large Scale Wind By A Regional Utility

**American Wind Energy Association
“Wind Forecasting and System Operations”**

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Abstract

This is a paper by the Bonneville Power Administration (BPA), a federal power marketing agency in the Pacific Northwest, in partnership with the National Renewable Energy Laboratory (NREL), Department of Energy (DOE) and BPA's forecasting vendor 3TIER Environmental Forecast Group (3TIER) of Seattle, Washington on the first year experience with forecasting wind energy in the BPA control area from real time to seven days ahead. This document is a follow up to the presentation by the Bonneville Power Administration June 6, 2006 to the American Wind Energy Association, as part of the "Wind Forecasting and System Operations" presentation section. BPA is now implementing a program to optimize its existing hydro and thermal generation assets to include the integration of large scale wind with the diverse uses of the Columbia and Snake River systems. An experimental RD&D Wind Forecasting Network project was started in April, 2005 to test the ability to forecast wind energy from BPA's 208 MW of existing wind in the day-two to day-five horizon needed by generation planning, along with meeting all environmental requirements of the power system.

BPA currently owns 75 percent of the high voltage transmission in the Pacific Northwest. An emerging facet of this study is an R&D effort to forecast large, unscheduled with-the-hour wind ramps occurring today and expected to increase as part of the integration of large scale wind (2400 MW) projected to be interconnected by BPA's transmission business line by the end of 2008. Estimated ramping projections approaching 50 percent of nameplate or higher may occur in the 10 to 40 minute time frame.

Benefits/Objectives

This presentation will help clarify the challenges with the integration and active management of large scale wind faced by a regional utility along with emerging issues with the coordination and optimization of existing generation assets. Though BPA functionally separated its generation and transmission assets to fulfill FERC Order 888 and 889, the agency remained operationally integrated. A regional Pacific NW transmission operator has not materialized.

The challenge for BPA is the coordination of its separated generation and transmission business lines. The integration of wind to serve statutorily and contractually obligated loads requires the ability to forecast wind in the planning horizon needed by the generation side of the organization. For large-scale wind to be simply moved across BPA's open access transmission system to meet other loads demands the generation inputs needed for ancillary services – without the benefit of knowing the schedules of this wind generation in advance – which may disrupt BPA's existing generation optimization. Transmission issues with congestion management and redispatch may also be impacted. This document (and subsequent presentation) will discuss how wind forecasting is evolving to meet the emerging needs for the integration of large scale wind in the time frames needed by both its power and transmission organizations.

Bonneville Power Administration – A Regional Utility

While BPA is part of the Department of Energy, it is not tax-supported through government appropriations. Instead, BPA recovers all of its costs through sales of electricity and transmission and repays the U.S. Treasury in full with interest for any money it borrows. BPA is a wholesale power marketing agency that owns no generation.



- Operates in five states – Washington, Oregon, Idaho, Montana and Wyoming
- Customers – Public Utilities, Investor Owned Utilities & Direct Service Industries
- 21,944 MW total capacity – 31 dams, 1 nuke, wind
- 19,321 MW system peak
- 7,712 aMW annual generation
- 15,342 miles of transmission 1000 – 115 kV (BPA owned)

The BPA Wind Forecasting Network

The BPA Wind Forecasting Network is a Research, Development and Demonstration (RD&D) project to test the value of hourly wind energy forecasts from real time to seven days ahead. The purpose is to inform the hydro optimization models that are currently in service – Columbia Vista, which optimizes generation and loads next hour, next day, weekly and seasonally (optimal dispatch) along with the Near Real Time Optimizer (NRTO) that optimizes generation to meet loads within the hour. Wind forecasts use the combined information from five operating BPA wind projects – Stateline, Klondike, Condon, Nine Canyon and Vansycle – along with the information from BPA's 60 meter Long-term Wind Monitoring sites to produce these forecasts. Please see attachment one for a diagram of this system.

An innovative data sharing agreement was made between the wind plant owner/operators to exchange wind plant data for the data from BPA's Long-term Wind Monitoring system. This data is sent real time to the wind forecasting vendor 3Tier Environmental Forecasting group in Seattle, Washington who then provides wind energy forecasts to BPA and the wind plants participating in the program. Data from a given wind facility is not available to any other wind project or to Bonneville's Power Business Line, maintaining important wind data confidentiality. The forecasts will be provided for two years starting April 15, 2005 and will end April 15, 2007.

Wind Energy Forecasts – 24/7, 365

Wind energy forecasts are produced 24 hours/day, 365 days/year, by the following schedule:

- *“Hour ahead” forecast:* For the next 8 operating hour forecasts will be made and updated every 10 minutes.
- *“Day ahead” forecast:* For the next 60 hours forecasts will be updated at least 3 times daily at 3 a.m., at 10 a.m. and at 3 p.m.
- *“Week ahead” forecast:* For the next 168 hours, forecasts will be provided and updated once daily by 6 a.m.
- *“Next week” forecast:* The historical average of wind plant output each hour after hour 168 to 336 hours.

The expected wind energy output will be detailed for each project on each hour. These wind energy forecasts are automatically input into BPA’s hydro optimization models Columbia Vista and NRTO to coordinate optimal river operations to meet expected loads and all environmental constraints. Please see attachment two for a typical hourly, daily and weekly forecast (BPA load serving wind only).

Forecast Results

To monitor the performance of the BPA Wind Forecasting Network, sophisticated monthly, weekly and daily wind energy forecast reports were developed to assess the accuracy of the forecasts. Please reference attachment three for a typical monthly, weekly and daily report.

Monthly Forecast Report: The accuracy of the forecasts is measured by the absolute value x (actual energy - forecasted energy)/project nameplate (MW). The division by the nameplate of the project was used so the large wind projects would not dominate the smaller facilities. Listed in the monthly report were the schedules received by the wind plant owner/operators. “Preschedule” means the 24 hour wind energy forecasts received by the BPA control area for the next operating day from the wind plant owner/operators. “Real time” means the allowed updates to the preschedule 20 minutes before the operating hour to update the expected wind energy for each project. A summary of the error of the wind energy forecasts and the schedules received by the wind plant owner/operators are listed to the immediate right of the attached table. Included is the error in the expected energy if the monthly average of each project was used in lieu of a wind energy forecast. The example of a typical monthly wind energy forecast summary was January 2006, a record wind energy production month with capacity factors > 60% for most projects. Please note the statistical error in the preschedules received by the wind plant owner/operators and the day one forecasts.

Weekly Forecast Report: Same as the monthly report using the same forecast parameters and error statistics. Please note the statistical error in the preschedules received by the wind plant owner/operators and the day one forecasts.

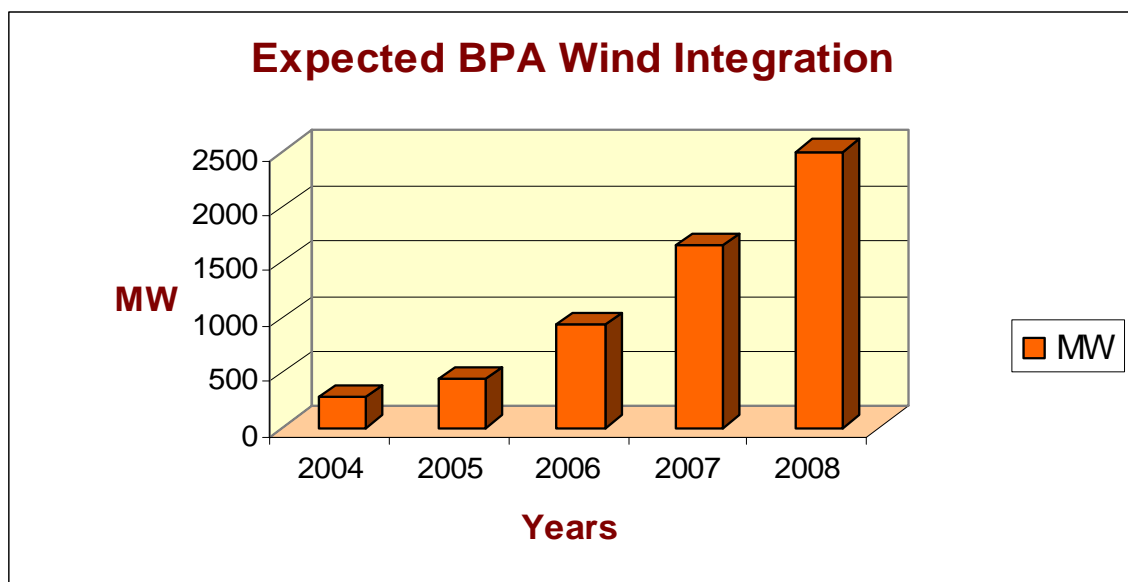
Daily Forecast Report: A measure of the daily wind energy forecast performance using the same forecast parameters as the monthly and weekly reports. The accuracy of the forecasts is measured as a percent of actual energy received from each project on an hourly basis. The report for 2/28/06 was selected to underscore that large ramps during the operating day are never scheduled accurately.

Special Note: The wind energy forecasts are sent to BPA and to the wind plant owner/operators by the same wind forecast vendor. An important discovery by BPA was that the wind plant owner/operators were not scheduling to the wind energy forecasts that they received.

The Unfolding Challenge of Large Scale Wind Integration

The BPA transmission system is highly constrained (please see attachment four). Consequently, to be able to get wind energy to loads, projects are locating in areas where commercial wind and transmission are available. What is occurring today is large wind projects are locating in small geographic areas. An assessment by BPA and one of its consultants (Oregon State University) determined wind regimes in the mid-Columbia basin that are likely to rise and fall together within the hour in the 10 to 40 time frame for most wind events (please see attachment five). The planned build out of new wind projects are occurring in these identified wind regime areas (please see attachment six for expected wind project development circa May, 2006 BPA Transmission Business Line website at <http://www.transmission.bpa.gov/PlanProj/Wind>).

Substantial wind is in process to be integrated by BPA by the end of 2008. It is expected that additional wind will request integration post 2008 as well.



Efficient Use of Available Resources

As mentioned earlier, large wind ramps are developing within the hour in the BPA control area and are expected to grow in magnitude as further wind is integrated by the agency (please see attachment seven). The challenge is these large changes in wind energy are not being accurately scheduled. Scheduling loads and generation a day ahead and updating before the operating hour is essential to efficient management of BPA's hydro and transmission assets. Since BPA remains operationally integrated, an inadvertent demand on system capacity is being made to implement the FERC 2005 mandate that transmission providers, such as BPA Transmission Business Line (TBL), integrate any and all renewable energy projects that request interconnection. For BPA's Power Business Line (PBL), some capacity and energy that would be available to sell during peak hours to get the best financial return (load factoring) is diverted to serve a real time need on the transmission system. Consequently, large scale wind integration has a potential revenue consequence to BPA's surplus sales that may be difficult to predict. A second generation wind forecast system is being considered along with other mitigation measures to manage this risk.

Proposed 2nd Generation BPA Wind Forecast System

BPA, along with its wind forecast vendor 3Tier, believe that the wind forecast system(s) currently in service today are not able to forecast wind ramps accurately in the preschedule time frame (a day ahead) up to real time. What is proposed is a wind ramping forecast in the preschedule that will identify hour(s) where the best meteorological wind forecasting identifies that a ramping event may occur. When the operating day starts, the wind ramp forecast is continuously updated. When a wind ramping period is imminent, ground based sensors such as up wind anemometry and ground based Radar dedicated to wind turn on to forecast the arrival of wind ramps in real time.

The foreknowledge of upcoming short term wind by both PBL and TBL will make efficient use of available Federal Columbia River Power System (FCRPS) resources. The expected benefits will include:

- Efficient use of hydro resources (PBL) – Columbia Vista & NRTO
- Less available capacity will be needed
- Efficient use of transmission assets (TBL) – congestion management, system stability, redispatch

The development of a wind ramping system identified and tracked in the preschedule, then monitored and tracked real time is R&D as no operational wind ramping forecasting system exists today. BPA research has indicated that this system may take 1 ½ to 2 years to develop. BPA has on going discussions with the California Independent System Operator and Southern California Edison, who are also engaged in similar short term wind forecasting efforts, to collaborate on the development a short term wind forecasting system to manage large and unscheduled wind ramps.

Conclusion

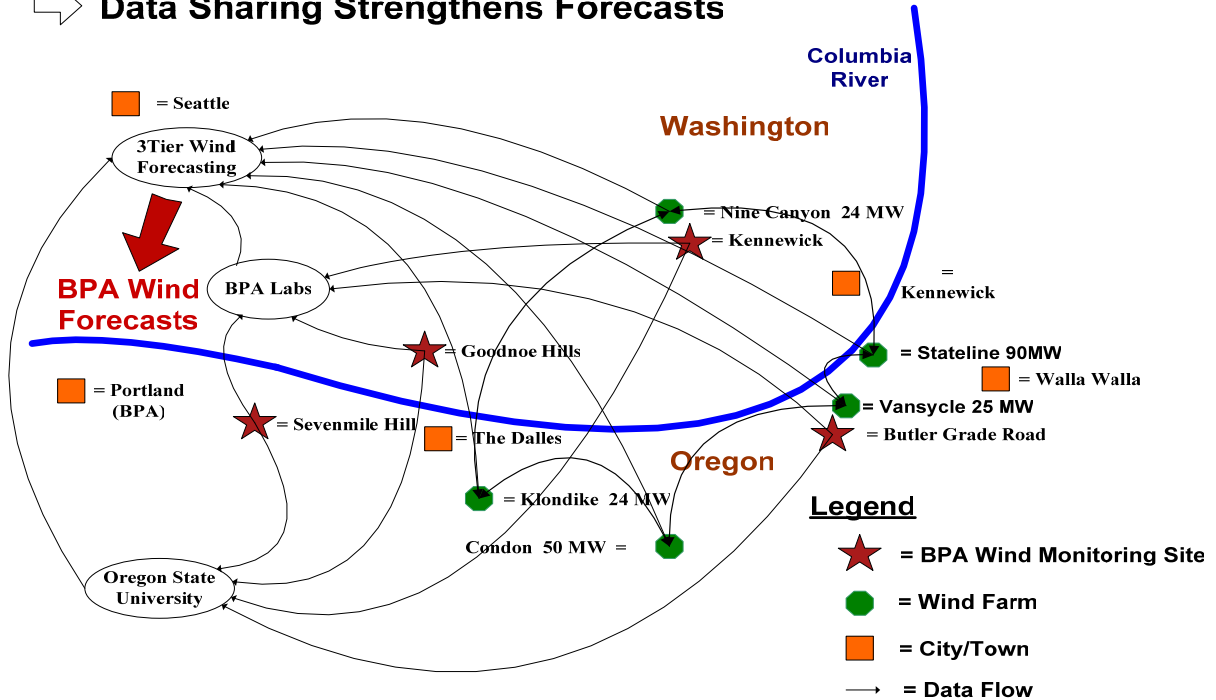
BPA will fulfill its historic role to find innovative solutions that serve the needs of its statutory and contracted customers. BPA is working with the Northwest Power and Conservation Council to develop a Pacific Northwest regional wind coordinating plan to manage the integration of large scale wind. This effort has just begun. BPA is also considering forecasting wind energy for wind projects in its control area along with developing a system to motivate the wind plant owner/operators to schedule to the forecasts. BPA is working today to create a partnership with its Generation (PBL) and Transmission (TBL) organizations to share wind energy data to meet their individual needs, yet maintain all Standards of Conduct (FERC) criteria. Through a Regional partnership, the value of wind energy will be fully realized to meet the needs of the Pacific Northwest.

Attachment One – BPA Wind Forecasting Network

BPA Wind Forecasting Network

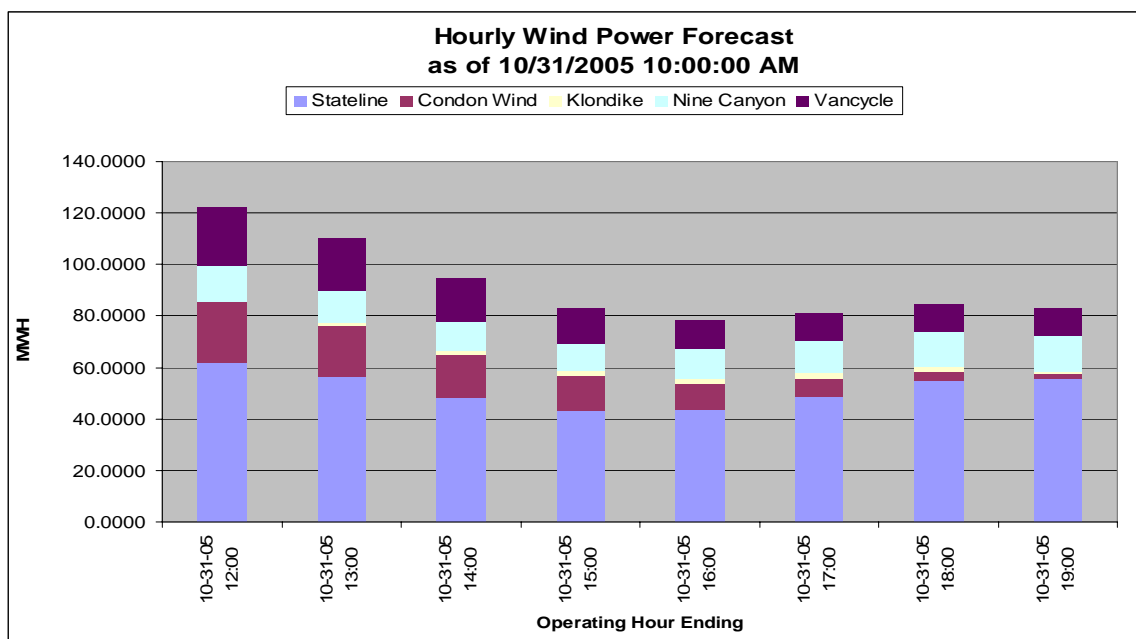
8/27/04

➔ Data Sharing Strengthens Forecasts

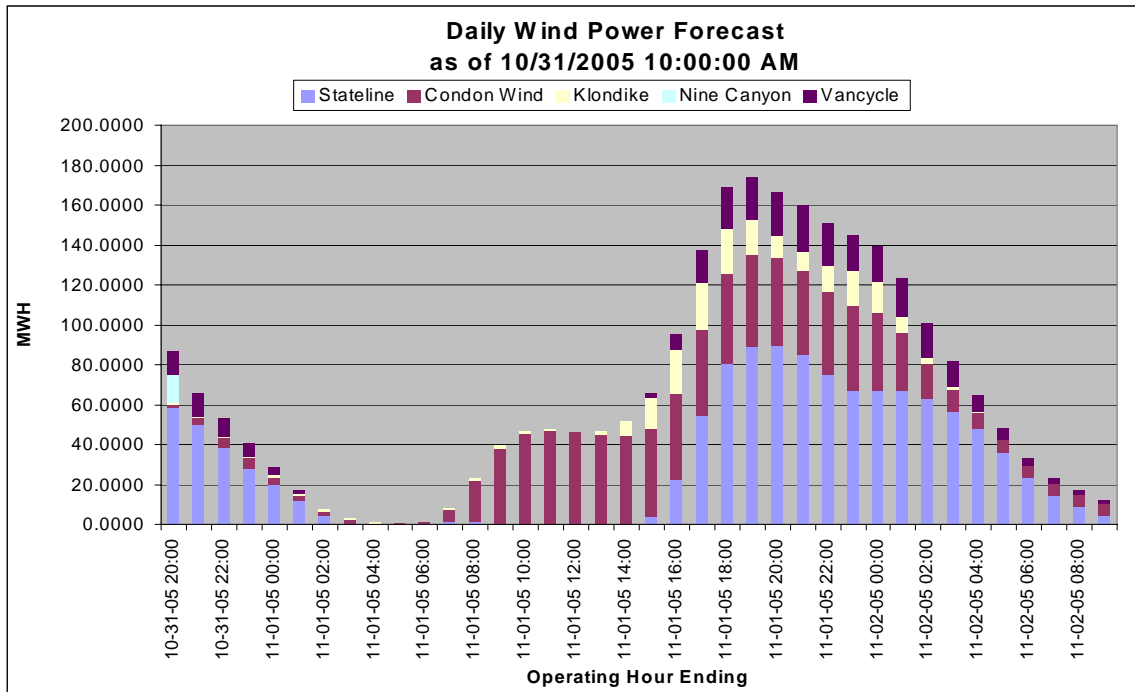


Attachment Two – BPA Wind Forecasts

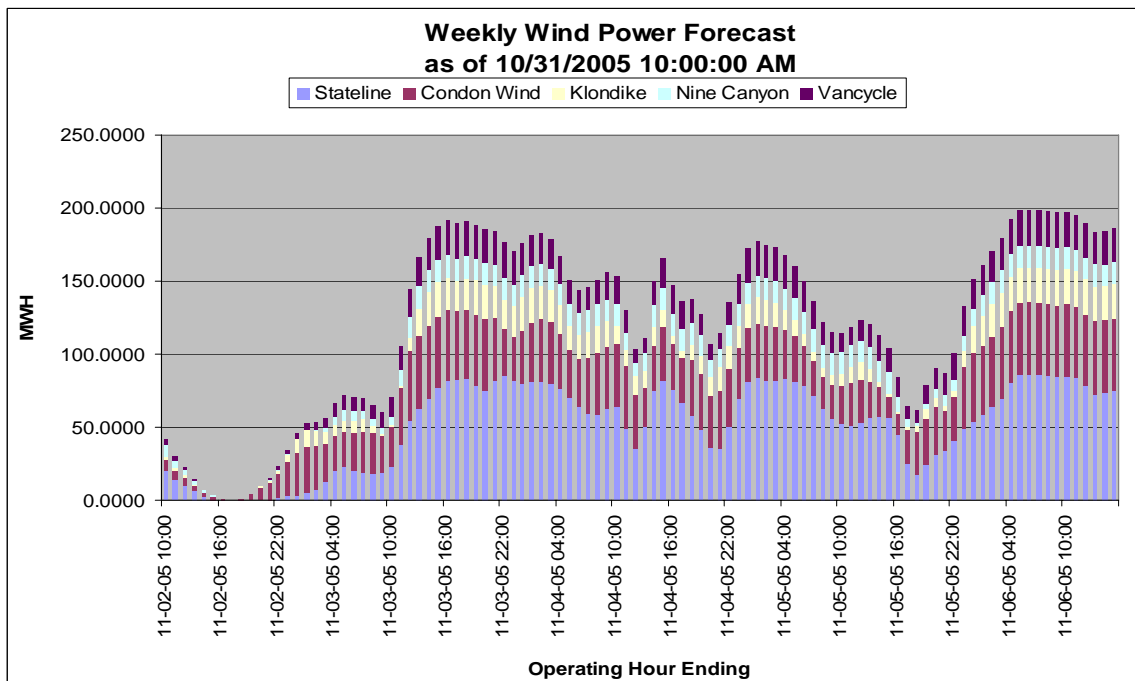
Hourly Wind Forecasts



Daily Wind Forecasts



Weekly Wind Forecasts

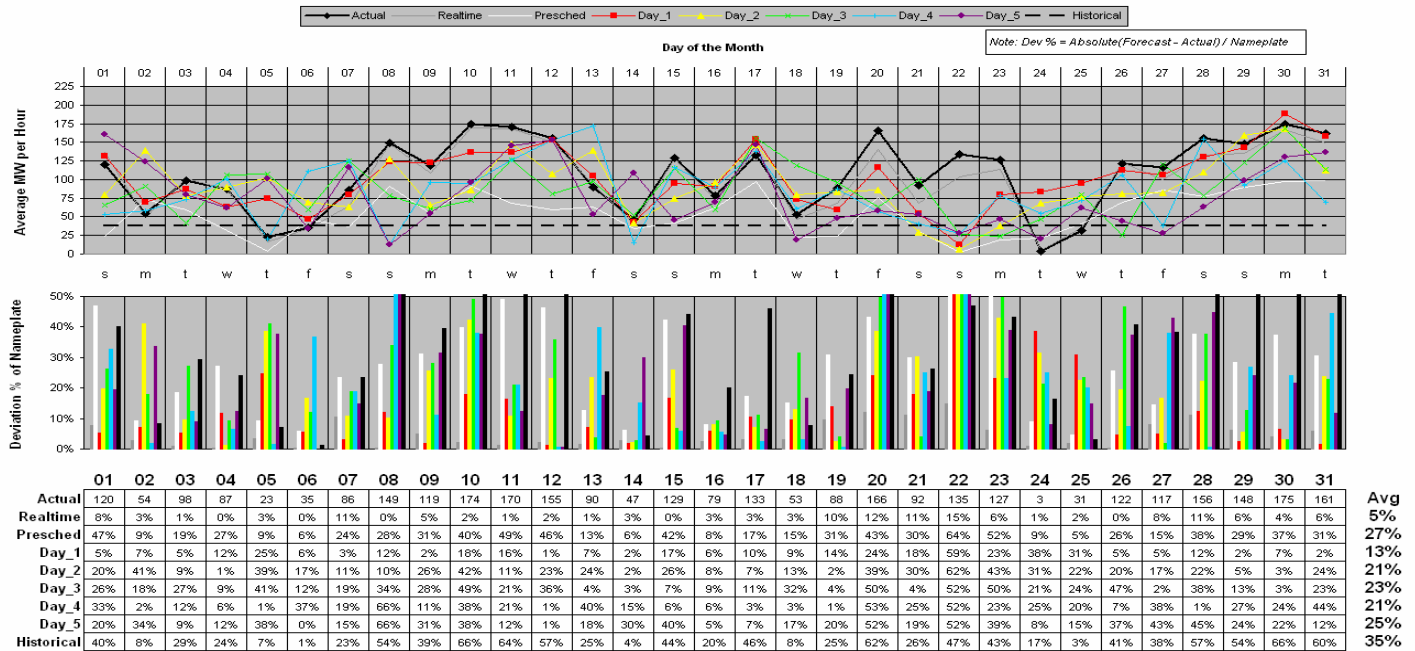


Attachment Three – Wind Forecast Reports

Monthly Forecast Report

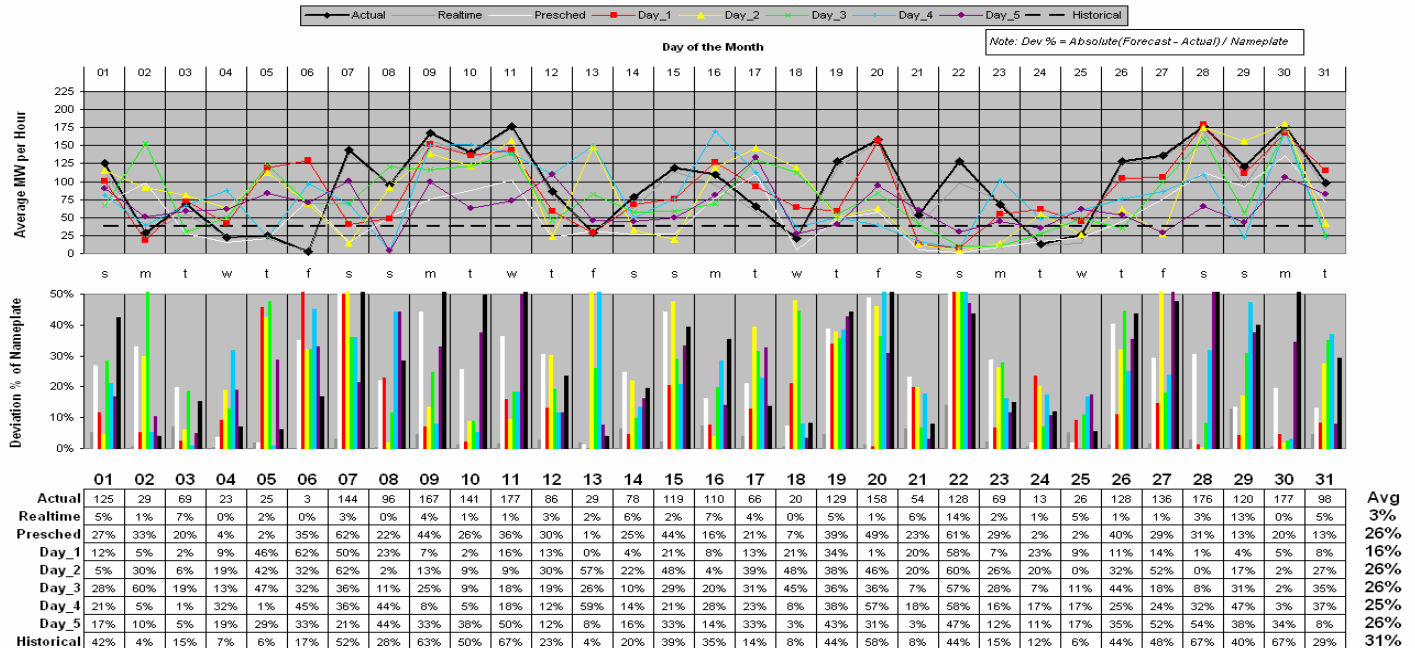
January 2006 Wind Power Forecasts to Actuals

Light Load (10PM to 6AM)



January 2006 Wind Power Forecasts to Actuals

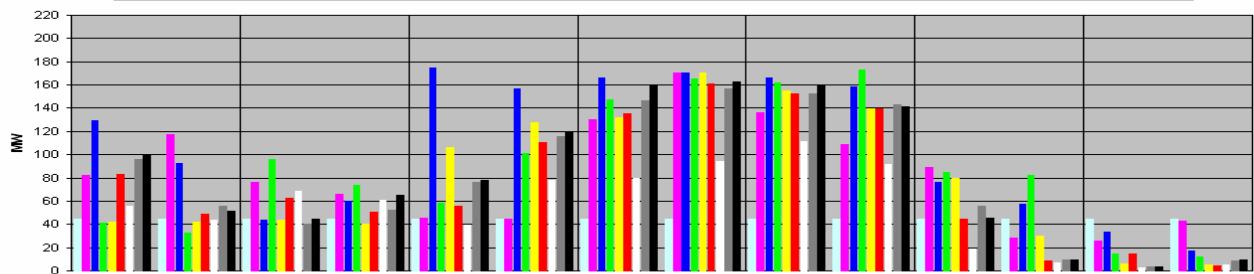
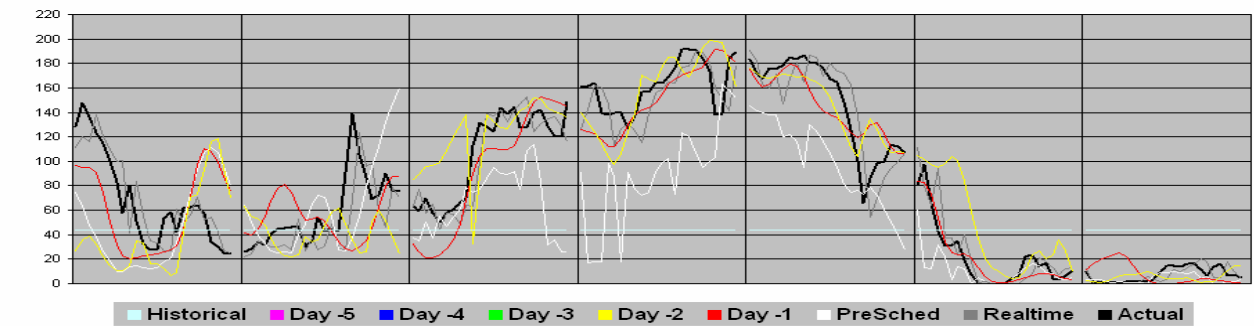
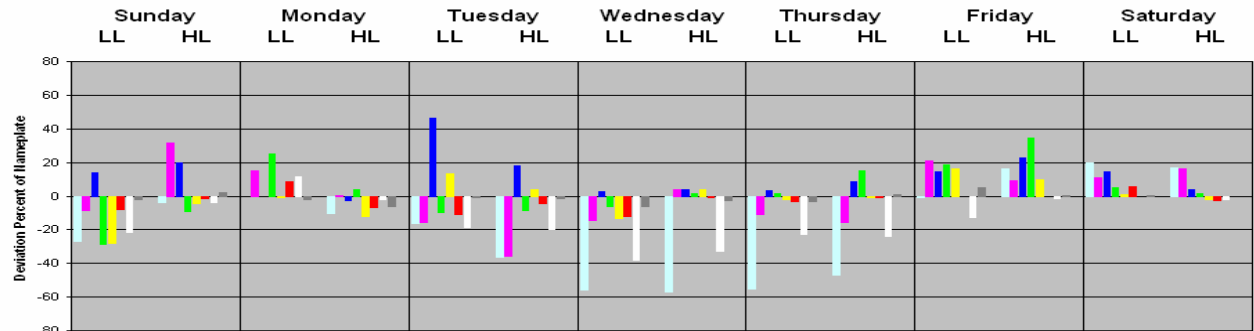
Heavy Load (6AM to 10PM)



Weekly Forecast Report

Weekly Summary Deviation Mar 05, 2006 to Mar 11, 2006

Note:
Light Load: 10PM - 6AM
Heavy Load: 6AM - 10PM

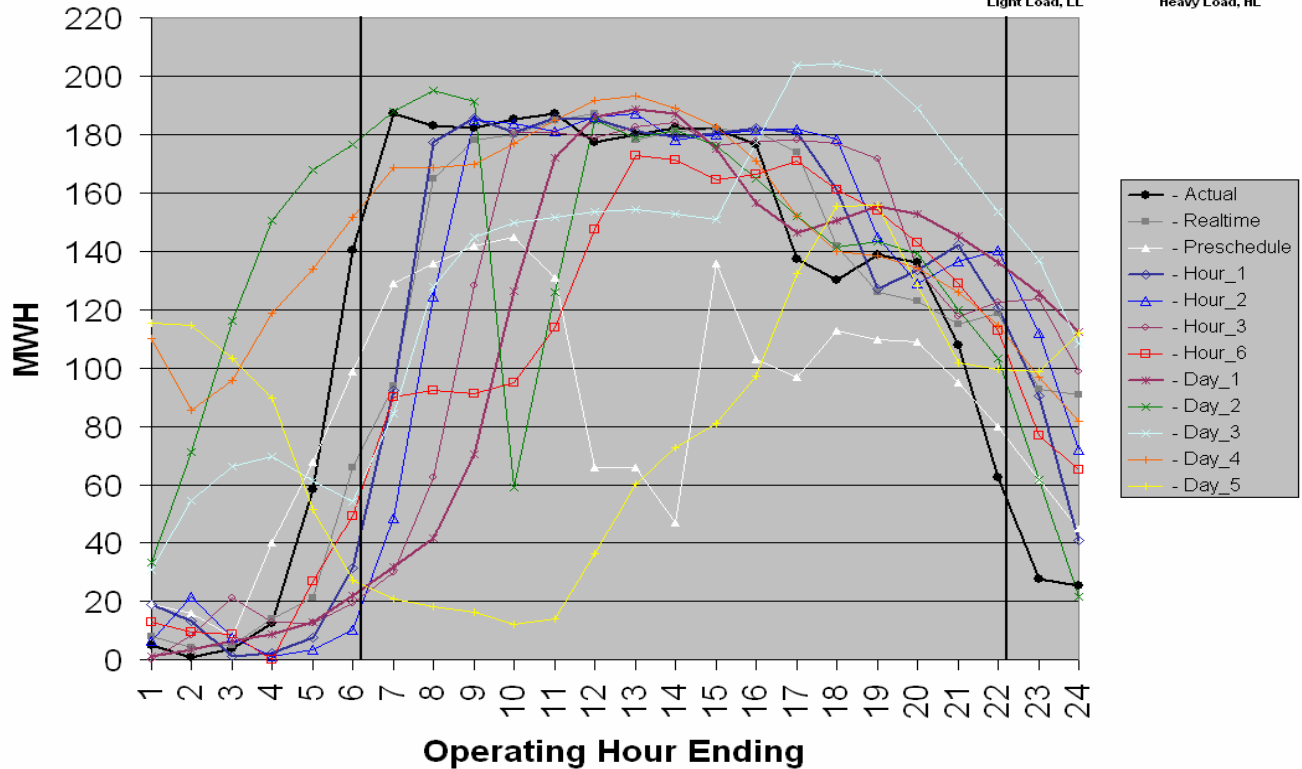
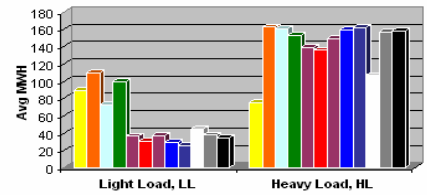


	Sunday		Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Absolute Average
	LL	HL	LL	HL	LL	HL	LL	HL	LL	HL	LL	HL	LL	HL	
Historical	44.1	44.1	44.1	44.1	44.1	44.1	44.1	44.1	44.1	44.1	44.1	44.1	44.1	44.1	25.8%
Day -5	-26.9%	-3.6%	-0.2%	-10.2%	-16.4%	-36.1%	-55.6%	-56.9%	-55.3%	-46.8%	-0.8%	16.5%	19.6%	16.7%	14.9%
Day -4	82.1	117.2	76.3	65.8	45.1	44.6	130.1	170.0	135.9	109.0	89.4	28.3	26.1	43.2	12.5%
Day -3	-8.6%	31.6%	15.2%	0.3%	-15.9%	-35.9%	-14.2%	3.7%	-11.1%	-15.6%	21.0%	8.9%	10.9%	16.3%	12.0%
Day -2	129.0	92.0	44.0	59.7	174.8	156.5	165.7	170.1	165.7	158.7	76.0	57.2	33.3	17.0	8.0%
Day -1	13.9%	19.5%	-0.3%	-2.7%	46.5%	17.9%	2.9%	3.7%	3.2%	8.3%	14.5%	22.9%	14.4%	3.7%	4.7%
PreSched	41.0	32.4	96.2	73.4	58.0	101.0	147.0	165.4	161.4	172.6	84.4	82.0	14.3	12.3	
RealTime	-28.4%	-9.2%	24.8%	3.9%	-9.7%	-8.8%	-6.1%	1.5%	1.2%	15.0%	18.6%	34.8%	5.3%	1.4%	
Actual	41.9	42.4	43.3	40.1	106.1	127.7	131.4	170.6	155.2	139.7	79.7	29.9	5.8	5.4	
	-28.0%	-4.4%	-0.6%	-12.1%	13.4%	4.1%	-13.6%	3.9%	-1.8%	-0.8%	16.3%	9.7%	1.2%	-1.9%	
	83.2	48.7	62.7	50.8	55.6	110.2	135.1	160.5	152.7	139.9	44.8	8.5	14.9	4.3	
	-8.1%	-1.3%	8.7%	-7.0%	-10.9%	-4.3%	-11.8%	-0.9%	-3.0%	-0.7%	-0.4%	-0.6%	5.6%	-2.4%	
	55.6	43.9	68.1	60.5	39.1	78.1	80.0	94.4	111.3	92.0	18.8	6.9	2.4	4.8	
	-21.3%	-3.7%	11.3%	-2.3%	-18.8%	-19.8%	-38.3%	-32.7%	-23.0%	-23.7%	-13.0%	-1.4%	-0.5%	-2.2%	15.1%
	95.9	55.6	40.4	52.1	76.3	115.7	146.4	156.7	152.6	143.1	56.0	9.8	3.8	8.3	2.4%
	-2.0%	2.0%	-2.0%	-6.4%	-1.0%	-1.7%	-6.4%	-2.8%	-3.1%	0.8%	4.9%	0.0%	0.2%	-0.5%	
	100.0	51.5	44.6	65.3	78.2	119.2	159.7	162.4	159.0	141.4	45.7	9.7	3.4	9.4	

Daily Forecast Report

February 2006						
Sat	Sun	Mon	Tue	Wed	Thu	Fri
28	29	30	31	1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	1	2	3
4	5	6	7	8	9	10

Daily Forecasts for February 28, 2006

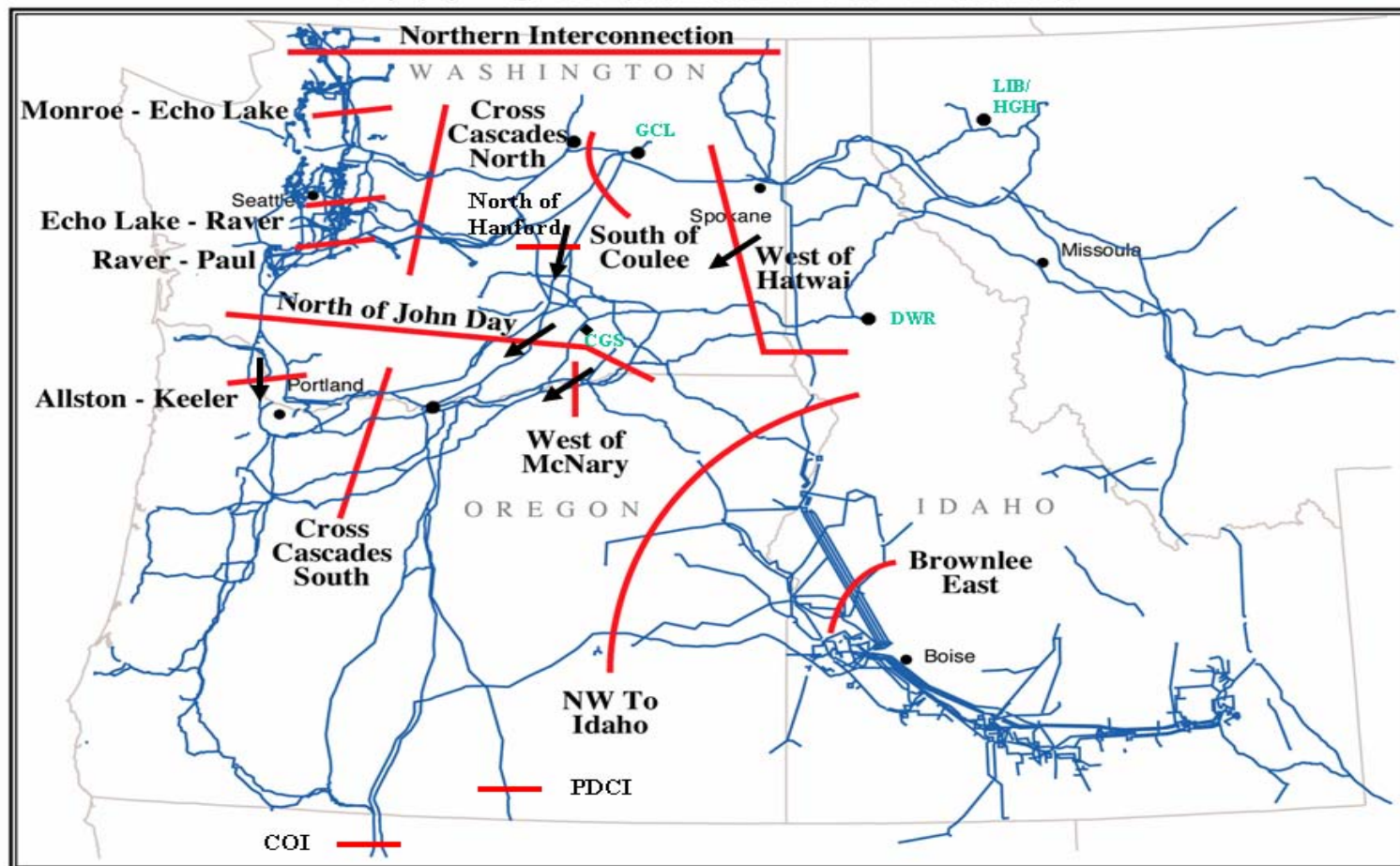


Forecast Percent of Actual

Note:
Light Load: 10PM - 6AM
Heavy Load: 6AM - 10PM

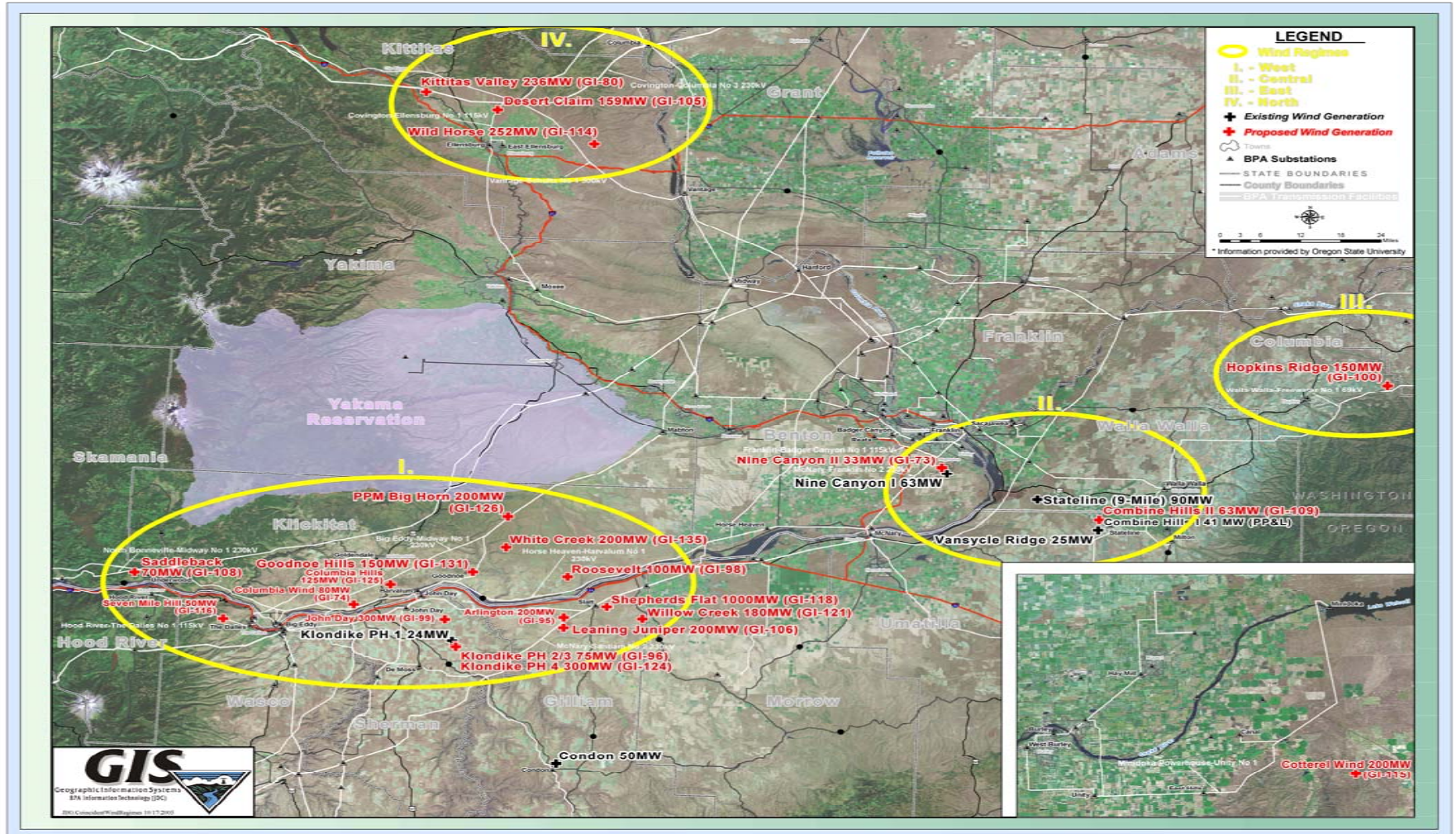
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	LL	HL
Realtime	162.6	425.5	136.2	113.9	36.0	47.0	50.2	90.2	97.7	97.1	98.9	105.3	98.9	99.4	100.0	102.6	126.7	109.1	90.6	90.4	106.4	189.5	336.5	360.4	110.4	99.0
Preschedule	386.1	####	217.9	325.4	116.4	70.4	68.9	74.4	78.0	78.2	70.0	37.2	36.7	25.8	74.8	58.4	70.6	86.8	79.1	80.1	87.9	127.4	224.3	178.2	130.5	67.2
Hour -1	380.1	####	29.5	17.9	12.6	22.4	49.4	97.0	101.8	97.5	99.2	104.4	100.6	98.5	99.1	103.3	131.7	123.9	91.4	98.1	131.5	192.1	327.6	161.7	75.0	102.3
Hour -2	129.9	####	205.2	10.2	5.6	7.3	26.0	68.2	101.5	99.2	96.9	104.7	104.0	97.8	98.9	102.8	132.4	137.2	104.3	94.8	126.5	223.5	404.9	286.0	85.6	100.4
Hour -3	0.0	867.5	570.8	104.6	21.6	13.7	16.0	34.3	70.5	97.5	96.7	100.7	101.4	101.2	96.9	100.7	129.8	136.0	123.6	98.6	109.0	195.1	448.3	392.1	108.5	94.0
Hour -6	258.1	992.2	241.1	0.0	45.8	35.2	48.1	50.5	50.1	51.3	60.9	83.0	96.1	94.1	90.4	94.3	124.6	123.8	110.7	105.1	119.5	179.5	278.1	258.6	91.1	85.8
(PreS) Day -1	26.6	359.9	174.3	69.5	21.9	15.7	16.9	22.6	38.7	68.2	92.0	104.8	104.7	102.8	96.2	88.7	106.7	115.6	112.0	112.3	134.2	216.8	454.6	445.5	106.9	87.6
Day -2	673.8	####	####	####	287.2	125.7	100.4	106.6	105.1	32.0	67.3	104.2	99.4	99.7	97.0	93.5	110.7	108.8	103.3	102.3	110.9	164.8	223.3	85.1	292.0	96.5
Day -3	623.9	####	####	568.6	105.5	38.7	45.2	70.0	79.6	80.8	81.2	86.5	85.8	83.8	83.1	100.5	148.5	156.8	144.7	139.0	158.1	244.5	495.2	429.5	213.0	101.4
Day -4	####	####	####	968.1	229.1	108.1	90.1	92.2	93.1	95.5	98.8	107.9	107.3	103.8	100.4	96.8	110.6	107.5	99.5	98.6	116.7	182.8	351.2	324.5	320.0	102.6
Day -5	####	####	####	730.8	88.2	19.2	11.0	9.9	9.0	6.6	7.4	20.4	33.5	39.9	44.6	55.1	96.5	119.6	112.2	94.2	94.2	158.7	357.5	444.0	260.4	47.4

NW Constrained Paths

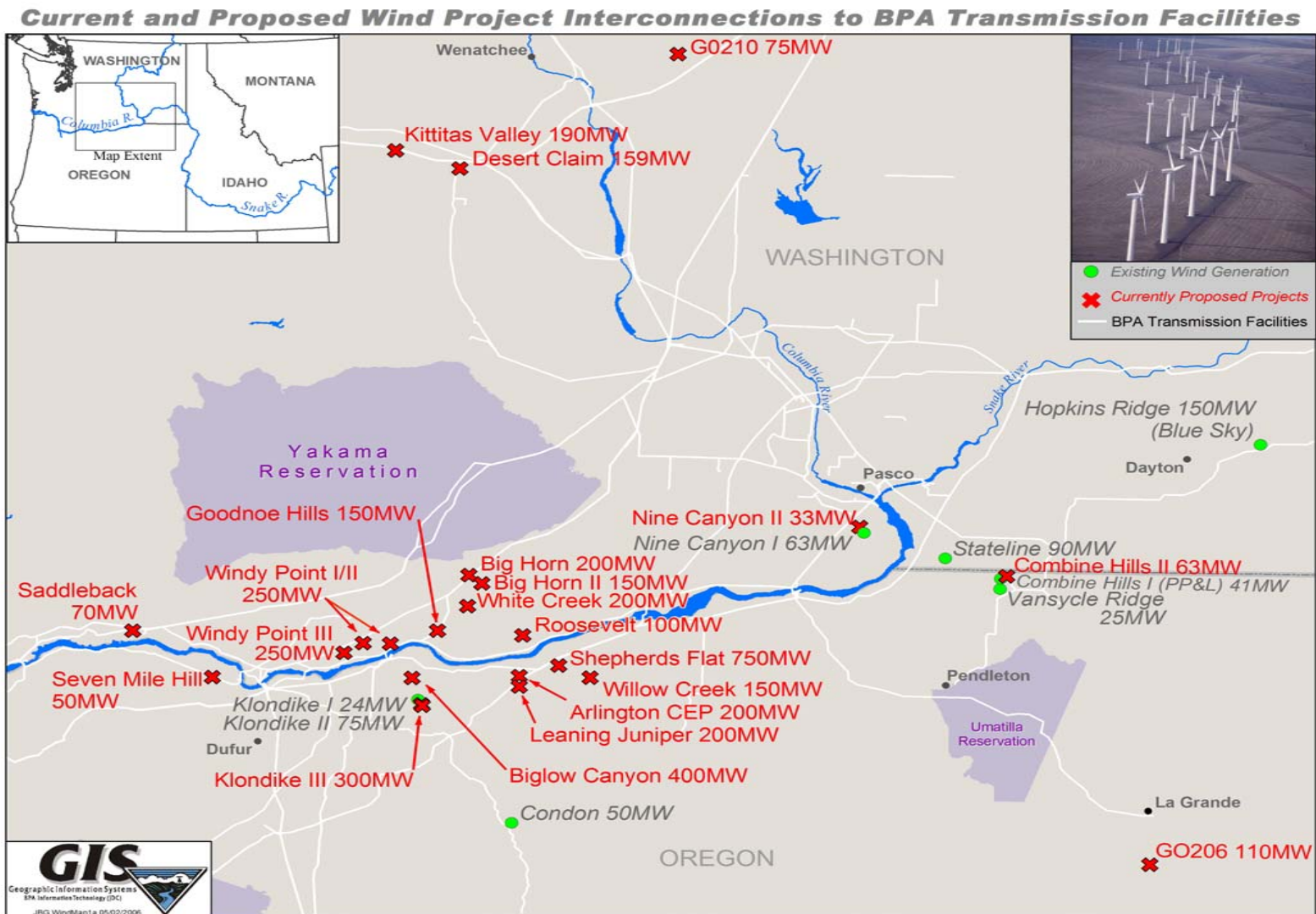


Attachment Five – Coincident Wind Regimes in the MidColumbia Basin

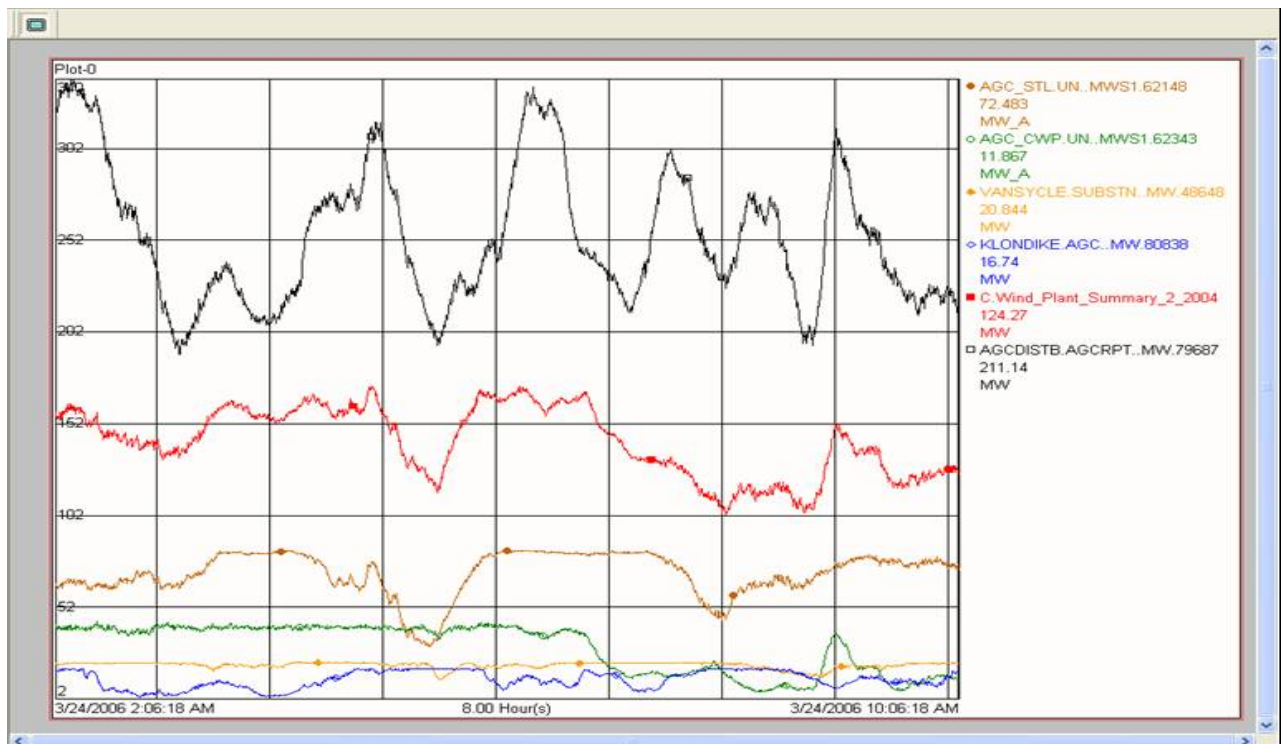
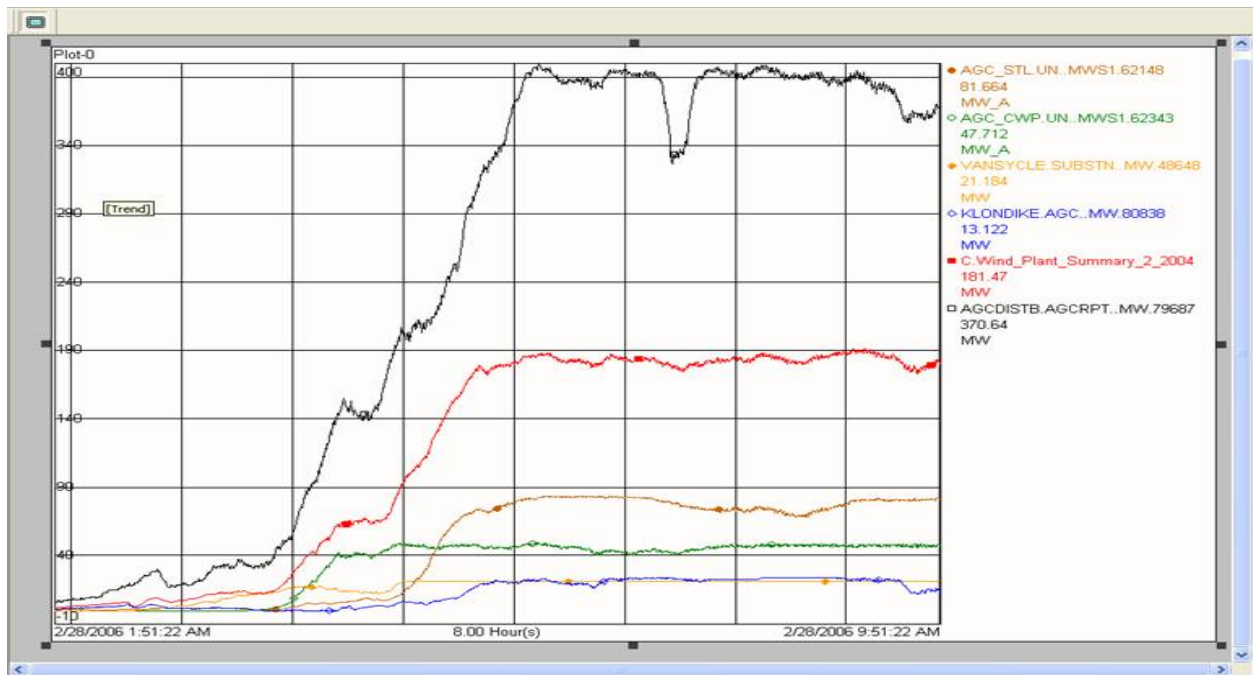
Coincident Wind Regimes



Attachment Six – Planned New Wind in the BPA Control Area (<http://www.transmission.bpa.gov/PlanProj/Wind/>)



Attachment Seven – Large Wind Ramps in the BPA Control Area (March 2006)



Discussion: Each block represents one hour and approximately 50 MW of wind energy. The red line is wind serving BPA load. The black line represents wind managed in the BPA control area. The other lines lower in each graph represent individual BPA projects.